METABOLIC SYNDROME IN TYPE 1 DIABETES

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CERTIFICATE

Certified that this dissertation entitled **"Metabolic Syndrome in Type 1 Diabetes"** is a bonafide work done by **DR.D.RENUMATHY**, MD Post graduate Student in Internal Medicine, Institute of Internal Medicine, Madras Medical College, Chennai- 600003, during the academic years 2005-2008.

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I solemnly declare that the dissertation **"Metabolic Syndrome in Type 1 Diabetes"** is done by me at Government General Hospital, Madras Medical College during 2005-2007 under the guidance and supervision of Prof. M.Jubilee, MD. This dissertation is submitted to the Tamil Nadu Dr.M.G.R Medical University towards the partial fulfillment for the award of **M.D degree in General Medicine** (Branch I).

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INTRODUCTION

Diabetes mellitus is a group of metabolic disorders with one common manifestation: *hyperglycemia*. Type 1 diabetes mellitus (formerly called type I, IDDM or juvenile diabetes) is characterized by beta cell destruction caused by an autoimmune process, usually leading to absolute *insulin deficiency*[1]. Over 95 percent of persons with type 1 diabetes mellitus develop the disease before the age of 25. Most of these patients have the "immune-mediated form" of type 1 diabetes mellitus with islet cell antibodies and often have other autoimmune disorders.[1]

The *Metabolic Syndrome* also called Insulin Resistance Syndrome or syndrome X, is a cluster of metabolically related cardiovascular risk factors, the core components of which comprise of central obesity, insulin resistance, dyslipidemia, and hypertension.[2] The presence of the metabolic syndrome predicts the risk of cardiovascular disease in nondiabetic subjects as well as in those with diabetes.[3] There are multiple definitions for the metabolic syndrome, with one of the recent ones being the consensus from the National Cholesterol Education Programme – NCEP ATP III Criteria.

A report from the National Cholesterol Education Program- Adult Treatment Panel (NCEP-ATP III) identified metabolic syndrome as an independent risk factor for cardiovascular disease and considered it an indication for intensive lifestyle modification. Metabolic syndrome is associated with a proinflammatory/prothrombotic state that may include

elevated levels of C-reactive protein, endothelial dysfunction, hyperfibrinogenemia, increased platelet aggregation, increased levels of plasminogen activator inhibitor 1, elevated uric acid levels, microalbuminuria, and a shift toward small, dense particles of low-density lipoprotein (LDL) cholesterol.

Central to the development of the metabolic syndrome appears to be the presence of increased insulin resistance. Although this is a characteristic usually associated with the development of type 2 diabetes, it can also be a feature of patients with type 1 diabetes.[4] When present in type 1 diabetes, the phrase "double diabetes" has been coined, with the assumption that these patients are likely to be at especially high risk of developing cardiovascular disease.[5]

The etiology of the metabolic syndrome has not been established definitively. One hypothesis presumes that the primary cause is insulin resistance. Insulin resistance correlates with visceral fat measured by waist circumference or waist to hip ratio. The link between insulin resistance and cardiovascular disease probably is mediated by oxidative stress, which produces endothelial cell dysfunction, promoting vascular damage and atheroma formation.

The second hypothesis blames hormonal changes for the development of abdominal obesity. One study demonstrated that persons with elevated levels of serum cortisol (caused by chronic stress)

developed abdominal obesity, insulin resistance, and lipid abnormalities. The investigators concluded that this inappropriate activation of the hypothalamic-pituitary-adrenal axis by stress is responsible for the link between psychosocial and economic problems, and acute myocardial infarction.

Diabetes in most cases is caused by a loss of the physical or functional ß-cell mass, mostly due to an autoimmune process (type 1 etiological process) and/or increased need for insulin due to insulin resistance (type 2 process) . Both of these major diabetes types are believed to include different stages of disease, ranging from non–insulin-requiring to insulin-requiring for control or survival. According to this classification adopted by the World Health Organization, it is quite possible that both processes would operate in a single patient and contribute to the phenotype of the patient. Also, factors other than autoimmunity can lead to a defective insulin response to glucose. Both major diabetes types are considered multifactorial diseases with several predisposing genetic and environmental factors, some of which could be common to both types. In populations with a high prevalence of type 1 diabetes, like in Finland, a large proportion of patients with type 2 diabetes should have inherited susceptibility genes for both types of diabetes. Also, the lifestyle changes leading to the type 2 diabetes

epidemic around the world may have an impact on the clinical picture of type 1 diabetes in the subjects at risk for type 2 diabetes as well.

The metabolic syndrome has been shown to confer an increased risk of cardiovascular disease in both the general and type 2 diabetic populations, but few studies have assessed the metabolic syndrome in type 1 diabetic patients. In a type 1 diabetic cohort, we assessed the prevalence of metabolic syndrome and tried to identify risk factors which predispose individuals to develop this constellation of findings.

REVIEW OF LITERATURE

The Metabolic Syndrome

Abnormalities in glucose and lipid metabolism, obesity, and high blood pressure occur together commonly enough in the same individuals as to suggest that they are somehow interrelated. In fact, this cluster of abnormalities has come to be known as a syndrome, going by a variety of names, including Syndrome X, the Deadly Quartet, and the Insulin Resistance Syndrome.

Metabolic syndrome was initially observed in 1923 by Kyln, who described the clustering of hypertension, hyperglycemia and gout as the syndrome. Reaven[6] first described syndrome X to comprise of central obesity, hyperinsulinemia, hyperuricemia, hypertriglyceridemia, and a propensity to coronary heart disease (CHD) and stroke. The insulin resistance syndrome (IRS) has since been expanded from this core phenotype to become increasingly recognized by physicians.

In 2001 NCEP ATP III formulated criteria to diagnose Metabolic Syndrome. IDF(International Diabetes Federation) has recently , in 2005, announced its own set of criteria which are slightly different from the NCEP criteria.

Aetiopathogenesis

The mechanisms underlying the metabolic syndrome are not fully known; however resistance to insulin stimulated glucose uptake seems to modify biochemical responses in a way that predisposes to metabolic risk factors.[7] A central role has been attributed to the pro-inflammatory cytokines, tumor necrosis factor a (TNF- a) and interleukin (IL)-6, supported by the fact that both are produced in substantial amounts by human adipose tissue. TNF-a impairs insulin-stimulated glucose uptake in a variety of cells and decreases lipoprotein lipase activity. Both cytokines increase hepatic lipogensis and elicit a systemic acute- phase response.[8]

Furthermore, various aspects of the acute-phase response, such as fibrinogen and plasminogen activator inhibitor-1 levels, whole-blood viscosity, and white blood cell count, have recently been found to correlate positively with the metabolic syndrome.[9] This is of particular interest because inflammation plays an important role in the pathogenesis of atherothrombosis.

Macrophage and T-cell infiltration is a major feature of atherosclerotic plaques, especially at sites of plaque rupture, and epidemiological studies show strong positive associations of systemic markers of inflammation with atherothrombotic disease.[10]

Moreover, C-reactive protein (CRP), the classic and exquisitely sensitive acute phase reactant, shows a strong independent association with the risk of Coronary Heart Disease and other atherothrombotic events. CRP levels have also been found to correlate with BMI and some features of the metabolic syndrome.

The AHA/NHLBI/ADA conference identified three potential etiologic categories:

1. Obesity and disorders of adipose tissue.

2. Insulin resistance.

3. A constellation of independent risk factors (e.g. molecules of hepatic, vascular and immunologic origin) that mediate specific component of syndrome like hypertension,

prothrombotic state,

lipoprotein metabolic ageing

and physical inactivity.

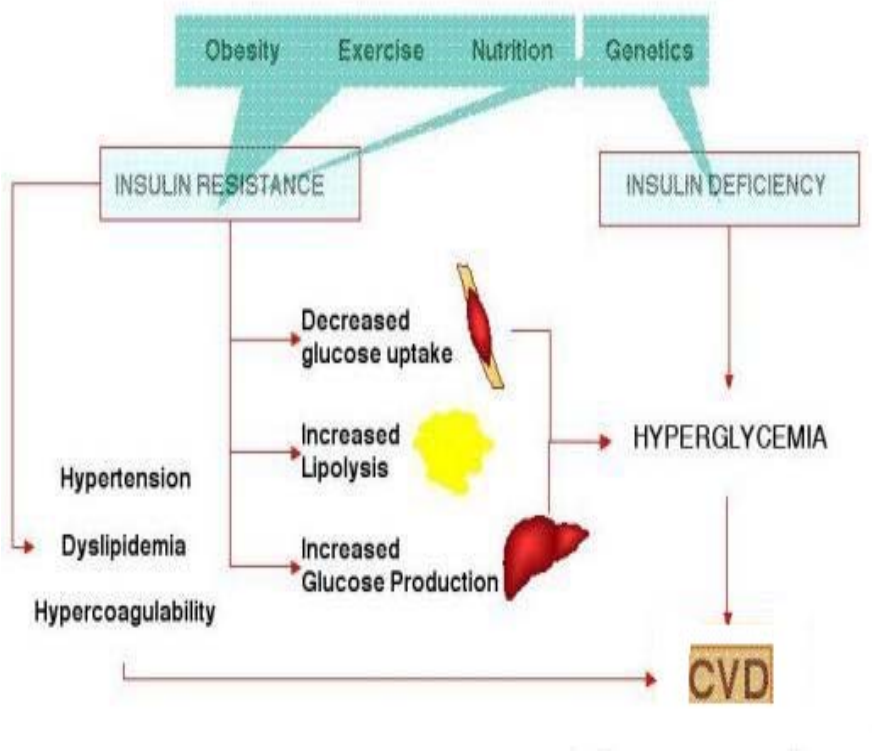

Figure 1 Shows the interaction among the various risk factors of cardiovascular disease.

Cardiovascular risk and Metabolic Syndrome:

The importance of the Metabolic syndrome lies in its consequences. The syndrome is typically characterized by varying degrees of glucose intolerance, abnormal cholesterol and/or triglyceride levels, high blood pressure, and central obesity, all independent risk factors for cardiac disease. If one includes along with the classic four features the commonly associated conditions of aging, sedentary lifestyle, stress, smoking, and a dose of genetic susceptibility, then a deadly web of increased cardiovascular disease risk is woven. In fact, the presence of any one major feature alone substantially increases the risk of heart

disease, but when they occur together the risk is magnified way out of proportion at the contribution of any one single factor.

This point was strikingly demonstrated by the PROCAM (Prospective Cardiovascular Munster) [11] Study, in which the relationship between various cardiac risk factors and the incidence of heart attack over a four year period was examined in 2,754 men aged 40-65 years. The results showed that the presence of diabetes or high blood pressure alone increased the risk of heart attack by 2.5 times. When both diabetes and high blood pressure were present, the risk was increased 8 times. An abnormal lipid profile increased the risk 16 times; when abnormal lipid levels were present with high blood pressure and/or diabetes, the risk was 20 times higher.

Hanna-Maaria Lakka, David E. Laaksonen,et al conducted a study in Finland to assess the association of the metabolic syndrome with cardiovascular and overall mortality. The Kuopio Ischaemic Heart Disease Risk Factor Study, a population-based, prospective cohort study of 1209 Finnish men aged 42 to 60 years at baseline (1984-1989) who were initially without CVD, cancer, or diabetes, was used for the study. The results conclusively showed that cardiovascular disease and all-cause mortality are increased in men with the metabolic syndrome, even in the absence of baseline CVD and diabetes.[12]

Christoph H. Saely, Stefan Aczel et al studies the impact of the MetS (Adult Treatment Panel III criteria) and insulin resistance (as estimated by the homeostasis model assessment index) on the incidence of vascular events. It was a prospective cohort study enrolling 750 consecutive patients undergoing coronary angiography for the evaluation of coronary artery disease at a tertiary care clinical research center. The main outcome measured was the incidence of vascular events over 2.3 yr. And they concluded that both the Metabolic syndrome and insulin resistance were strong and mutually independent predictors of vascular risk among angiographed coronary patients.[13]

Metabolic syndrome and Type 2 Diabetes:

Bo Isomaa, Peter Almgren, Tiinamaija Tuomi et al conducted a study to find out the prevalence of and the cardiovascular risk associated with the metabolic syndrome using the new definition proposed by the World Health Organization (WHO). A total of 4,483 subjects aged 35–70 years participating in a large family study of type 2 diabetes in Finland and Sweden (the Botnia study) were included. Cardiovascular mortality was assessed in 3,606 subjects with a median follow-up of 6.9 years. In women and men, respectively, the metabolic syndrome was seen in 10 and 15% of subjects with NGT, 42 and 64% of those with IFG/IGT, and 78 and 84% of those with type 2 diabetes.

The risk for coronary heart disease and stroke was increased threefold in subjects with the syndrome ($P < 0.001$). Cardiovascular mortality was markedly increased in subjects with the metabolic syndrome (12.0 vs. 2.2%, $P < 0.001$). Of the individual components of the metabolic syndrome, microalbuminuria conferred the strongest risk of cardiovascular death (RR 2.80; $P = 0.002$).Their study results clearly showed that the WHO definition of the metabolic syndrome identifies subjects with increased cardiovascular morbidity and mortality and offers a tool for comparison of results from different studies.[14]

From the above studies quoted an association between type 2 DM, Metabolic Syndrome and Cardiovascular risk have been shown to be clearly established.

Type 1 Diabetes Mellitus:

Type 1 diabetes is an autoimmune disease that results in the permanent destruction of insulin producing beta cells of the pancreas. This etiology makes type 1 distinct from type 2 diabetes mellitus. Type 1 is lethal unless treatment with exogenous insulin via injections replaces the missing hormone.

Chronic complications of Type 1 Diabetes are similar to those seen in Type 2 DM. The vascular complications are divided into microvascular

(retinopathy, neuropathy, nephropathy) and macrovascular (coronary artery disease, cerebrovascular disease, peripheral vascular disease).

The DCCT, UKPDS and Kumamoto study support the idea that chronic hyperglycemia plays a causative role in the pathogenesis of diabetic microvascular complications but evidence implicating a causative role for the same in the development of macrovascular complications is less conclusive .[15] Intensive Insulin therapy has been shown to effectively delays the onset and slow the progression of diabetic retinopathy, nephropathy, and neuropathy in patients with IDDM.[16] A study on the Effect of intensive diabetes management on macrovascular events and risk factors in the Diabetes Control and Complications Trial showed that intensive insulin therapy showed a reduction in some but not all cardiovascular risk factors in Type 1 DM.[17]

Other factors like dyslipidemia and hypertension play important roles in macrovascular complications. 10-year follow-up data from the Pittsburgh Epidemiology of Diabetes Complications study showed that Insulin Resistance–Related Factors, but not Glycemia, Predict Coronary Artery Disease in Type 1 Diabetes.[18] So the presence of metabolic syndrome will considerably increase the risk of cardiovascular adverse events in patients with Type 1 DM.

Both the microvascular and macrovascular complications translate directly into increased morbidity and mortality among these young

patients with Type 1 DM. A follow-up study of 1966 patients with insulin-dependent diabetes mellitus (IDDM) who were diagnosed at Children's Hospital of Pittsburgh (CHP) between 1950 and 1981 showed a sevenfold excess in mortality compared with the U.S. population. After age 20, the annual mortality risk was approximately 2%, which was more than 20 times greater than for the U.S. population.[19]

Sabita S. Soedamah-Muthu, John H. Fuller, et al estimated the Risk of Cardiovascular Disease in Patients With Type 1 Diabetes in the U.K. Subjects with type 1 diabetes (n = 7,479) and five age- and sex-matched subjects without diabetes (n = 38,116) and free of CVD at baseline were selected from the General Practice Research Database (GPRD), a large primary care database representative of the U.K. population. Incident major CVD events, comprising myocardial infarction, acute coronary heart disease death, coronary revascularizations, or stroke, were captured for the period 1992–1999. This data showed that absolute and relative risks of CVD remain extremely high in patients with type 1 diabetes. Women with type 1 diabetes continue to experience greater relative risks of CVD than men compared with those without diabetes.[20]

The risk of mortality from ischemic heart disease is exceptionally high in young adult women with Type 1 diabetes, with rates similar to those in men with Type 1 diabetes under the age of 40. These observations emphasize the need to identify and treat coronary risk

factors in these young patients. These conclusions were drawn in a study on ‘Mortality from heart disease in a cohort of 23,000 patients with insulin-treated diabetes.’ Conducted using the database of ‘Diabetes UK cohort’.[21]

Magnitude of the problem:

Type 1 Diabetes is a relatively rare disease. The prevalence of type 1 diabetes mellitus in India is 10.1-10.6 per hundred thousand.[22] The crude prevalence rate of diabetes in urban areas is about 9% and that the prevalence in rural areas has also increased to around 3% of the total population. The type of diabetes which we see in India is considerably different from that described in the western literature. Although the estimate of Type 1 is around 1% of the total diabetics, the vast majority of the so-called Type 1 differ significantly from their western counterparts.

Metabolic syndrome is a very commonly found condition in the Indian adult population especially among patients with Type 2 DM. Metabolic syndrome is highly prevalent among urban Indians (41.1 %). Its prevalence increased with age and was higher among women.[23] Age wise prevalence for metabolic syndrome is not available.

Table 1 Showing prevalence of metabolic syndrome in India by various studies. Adapted from Misra A , Met Syndrome and related disorders, 2004.

Author, Year, City.	PREVALENCE		
	O	M	F
Kasliwal et al, 2005, Delhi	28.5	-	-
Gupta et al, 2004, Jaipur	25	18	31
Misra et al, 2004, Delhi	12	8	15
Gupta et al, 2003, Jaipur	13	10	20
Ramachandran et al , 2003, Chennai	41	-	-

The prevalence of Metabolic syndrome among Type 1 diabetics has been described to vary from 17% to 40% by various studies.[24-25] No data was found describing the occurrence of this complication among Indian patients with Type 1 DM, which is the aim of this study.

Identification of Metabolic Syndrome.

Various criteria are in current clinical practice to identify patients with Metabolic syndrome. The more commonly used ones are WHO criteria, NCEP ATP III criteria and IDF criteria.

WHO was the first to publish internationally accepted criteria for Metabolic Syndrome in 1998.The **WHO criteria** are as follows:

1. **High insulin levels**, an elevated fasting blood glucose or an elevated post meal glucose alone with at least 2 of the following criteria:

   Abdominal obesity as defined by a waist to hip ratio of greater than 0.9, a body mass index of at least 30 kg/m2 or a waist measurement over 37 inches.
2. **Cholesterol** panel showing a triglyceride level of at least 150 mg/dl or an HDL cholesterol lower than 35 mg/dl.
3. **Blood pressure** of 140/90 or above (or on treatment for high blood pressure).

But the criteria that have received the most widespread acceptance and use are those proposed by **NCEP ATP III**. The criteria are :

- Central/abdominal obesity as measured by waist circumference [Men - Greater than 40 inches (102 cm); Women - Greater than 35 inches (88 cm)]
- Fasting triglycerides greater than or equal to 150 mg/dL (1.69 mmol/L)
- HDL cholesterol [Men - Less than 40 mg/dL (1.04 mmol/L); Women - Less than 50 mg/ dL (1.29 mmol/L)]
- Blood pressure greater than or equal to 130/85 mm Hg
- Fasting glucose greater than or equal to 110 mg/dL (6.1 mmol/L).

In this study we have used the NCEP ATP III as it is the one found to be most applicable in this setup. All the risk factors have been compiled based on the NCEP ATP III only.

The **IDF criteria** is the most recent criteria and here abdominal obesity has been used as a mandatory requisite. According to the new IDF definition, for a person to be defined as having the metabolic syndrome they must have:

- Central obesity (defined as waist circumference > 94cm for Europoid men and > 80cm for Europoid women, with ethnicity specific values for other groups) plus any two of the following four factors:

- raised TG level: > 150 mg/dL (1.7 mmol/L), or specific treatment for this lipid abnormality
- reduced HDL cholesterol: < 40 mg/dL (1.03 mmol/L*) in males and < 50mg/dL (1.29 mmol/L*) in females, or specific treatment for this lipid abnormality
- raised blood pressure: systolic BP 3 130 or diastolic BP 3 85 mm Hg, or treatment of previously diagnosed hypertension
- raised fasting plasma glucose (FPG) > 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes. If above 5.6 mmol/L or 100 mg/dL, OGTT is strongly recommended but is not necessary to define presence of the syndrome.

From the above discussion it is clear that Metabolic syndrome is achieving epidemic proportions in India. And with various studies clearly demonstrating an absolute increase in cardiovascular risk with the occurrence of this constellation of factors, occurrence of metabolic syndrome is turning out to be a harbinger of major complications.

Type 1 DM though is a rare disease, is one that afflicts the young population of our country. These patients, if diagnosed early and managed effectively with insulin therapy and regular follow up to detect complications, can live a productive and fulfilling life.

The concept of insulin resistance playing a role in the complications occurring in these insulin deficient patients is a relatively new one. But there are studies which have elegantly showed that the metabolic syndrome does occur in these patients thus multiplying their cardiovascular risk. But data on this subset of patients and what causes them to develop insulin resistance in the Indian scenario is sparse.

So, **this study has been undertaken to estimate the prevalence of Metabolic syndrome among patients with type 1 DM using the NCEP ATP III criteria.** We have attempted to identify risk factors for the same.

The results of this study will not only estimate the prevalence and risk factors but will be useful to understand better the pathophysiological

mechanisms underlying the Metabolic Syndrome not only in type 1 diabetics but also in the general population and in those with Type 2 DM.

Early identification of Metabolic syndrome in Type 1 diabetics can help to aggressively initiate lifestyle modifications and therapeutic interventions to decrease the morbidity and mortality associated with this disease.

METHODOLOGY

AIMS AND OBJECTIVES

1. To estimate the prevalence of Metabolic syndrome among patients with Type 1 Diabetes Mellitus.
2. To identify the risk factors predisposing patients with type 1 DM to develop Metabolic Syndrome.

MATERIALS AND METHODS

- **Setting** – Out Patient Department, Department of Diabetolgy, Government General Hospital, Madras Medical College, Chennai

- **Collaboration Departments**- Department of Diabetology, Government General Hospital, Madras Medical College, Chennai

- **Ethical committee Approval**- Obtained

- **Design of study**- Descriptive Study

- **Period of study**- January 2006- June 2007

- **Sample size**- 100 patients

Maneuver:

The study was carried out in the out patient clinic of the Department of Diabetology. Type 1 Diabetes patients who were registered there were enrolled for the study after obtaining their consent. A total of 100 patients were selected as per the Inclusion and Exclusion criteria.

Patient's socio demographic data was recorded in the proforma sheet. The duration of their diabetes and the current insulin requirement per day were noted. Since HbA1c was not available the status of their glycaemic control was determined by taking an average of their monthly Fasting Blood Sugar values over a period of one year[33].

Physical measurements, with the participants in bare feet and in light clothing, included height measured to the nearest centimetre, and weight to the nearest 10th of a kilogram (1 kg was deducted from the weights recorded as an allowance for clothing).

Waist circumference was measured around the narrowest point between ribs and hips when viewed from the front after exhaling. Hip circumference was measured at the point where the buttocks extended the maximum, when viewed from the side. Two consecutive recordings were made for each site to the nearest 1 cm using an inch tape on a horizontal

plane without compression of skin. The mean of two sets of values was used.

Blood pressure levels were obtained using mercury sphygmomanometers on the right arm of seated subjects. Systolic and phase 4 diastolic pressures were taken twice to the nearest 2 mmHg and the average recorded.

Fasting blood samples collected into heparinised tubes and sent to the Central Laboratory, Institute of Biochemistry, Madras Medical College. Plasma cholesterol and triglyceride levels were determined by colorimetric methods, and high-density lipoprotein (HDL) cholesterol level assayed in the supernatant after polyethylene glycol precipitation. Levels of low-density lipoprotein (LDL) cholesterol were calculated by the Friedewald formula if the total triglyceride level was < 4.5 mmol/L.

Selection of study subjects

- **Inclusion criteria-** Patients with Type 1 Diabetes Mellitus
- **Exclusion criteria-**
    1. Patients on treatment with lipid lowering drugs
    2. Pregnant patients
    3. Patients with other endocrine disturbances.
    4. Patients on drugs which can cause hyperglycemia, hypertension or hyperlipidemia.

Definitions:

Type 1 Diabetes Mellitus-

A form of diabetes mellitus in which the insulin- secreting capacity of pancreatic ß-cells is completely destroyed.

In this study we have identified patients in whom onset of diabetes occurred before the age of 25 yrs and who became insulin dependent within one year of starting treatment.

Diabetes Mellitus is characterized by recurrent or persistent hyperglycemia and is diagnosed by demonstrating **any one** of the following:

- Fasting Plasma Glucose at or above 126 mg/dl
- Random Plasma glucose at or above 200mg/dl plus symptoms of diabetes.

Poor glycemic control

Was defined as the average of fasting blood sugar done at monthly intervals over one year of more than 140 mg/dl[33].

Metabolic syndrome:

According to the **NCEP ATP III criteria**, the metabolic syndrome is presence ***of 3 or more*** of:

1. Central obesity as measured by waist circumference:

   Men >40 inches (102 cms): Women >35 inches(88 cms)

2. Fasting blood triglycerides > 150 mg/dL
3. Blood HDL cholesterol: Men<40 mg/dL: Women<50 mg/dL
4. Blood pressure > 130/85 mmHg or documented use of antihypertensives.
5. Fasting glucose >110 mg/dL

Physical activity: A questionnaire on the daily physical activity level was used to classify people into heavy physical work, moderate physical activity and sedentary lifestyle.

Hypothesis:

Type 1 diabetes mellitus (DM1) is due to the autoimmune destruction of beta cells within the pancreatic islets. In contrast to DM1, which has an autoimmune cause, the underlying defect that causes type 2 diabetes (DM2) is insulin resistance. Normally, insulin acts as a signal to promote glucose uptake and metabolism in the muscle. However, the muscle of people with DM2 is resistant to this signal. Therefore the insulin-secreting pancreatic beta cells have to increase production to increase the insulin signal to the defective muscle. As the patient's insulin resistance becomes more severe over time, the pancreatic beta cells are eventually exhausted and fail. At that point, blood glucose levels start to rise and type 2 diabetes can be diagnosed. People with type 2 diabetes have an underlying genetic predisposition towards insulin resistance. There are 3 factors that cause insulin resistance to worsen and lead to DM2: aging, gaining weight, and becoming more sedentary.

It is quite possible to have a patient who develops DM1 due to autoimmune destruction of beta cells who also has the genetic predisposition for insulin resistance. Therefore, if this patient gains weight and becomes more sedentary, insulin resistance and features of the dysmetabolic syndrome could occur. As DM1 patients with the genetic predisposition for insulin resistance gain weight and become more

sedentary, they could require higher doses of insulin. Furthermore, they may also have increased cardiovascular risk. People with insulin resistance have been shown to have lower protective HDL cholesterol levels, higher plasminogen activator inhibitor 1 (PAI-1) levels and higher C-reactive protein (CRP) levels (indicating vascular inflammation). Thus, treating the insulin resistance could have theoretical potential for lowering insulin requirements and could possibly lessen cardiac risk in DM1 in patients with features of the dysmetabolic syndrome.

Type 1 and type 2 diabetes frequently co-occur in the same families, suggesting common genetic susceptibility. In populations with a high prevalence of type 1 diabetes, like in Finland, a large proportion of patients with type 2 diabetes should have inherited susceptibility genes for both types of diabetes. Also, the lifestyle changes leading to the type 2 diabetes epidemic around the world may have an impact on the clinical picture of type 1 diabetes in the subjects at risk for type 2 diabetes as well. According to the "accelerator hypothesis," there are two accelerators precipitating disease in all types of diabetes: the intrinsically high rate of ß-cell apoptosis and insulin resistance resulting from weight gain and physical inactivity.

RESULTS

In our study group of 100 patients 21 patients were found to have Metabolic Syndrome as defined by NCEP ATP III criteria.

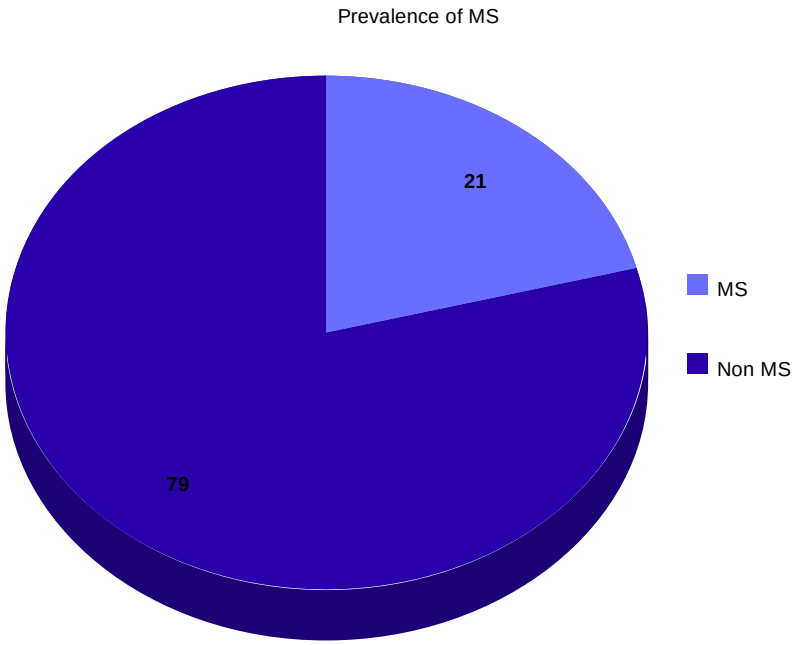

Figure 2 Prevalence of Metabolic Syndrome in the study group

Age :

The mean age of the patients in the study group was 28.0 yrs ±1.99.The mean age of the patients with Metabolic syndrome is 35.29 years (±12.44) and the mean age for those without is 26.65 years (±8.70). On using the Student t – test we found a statistically significant association between age of the patient and occurrence of metabolic syndrome.

Table 2 Age distribution among the study group

TYPE	AGE		P VALUE
	MEAN	SD	
MS	35.29	12.44	<0.001
Non MS	26.65	8.70	

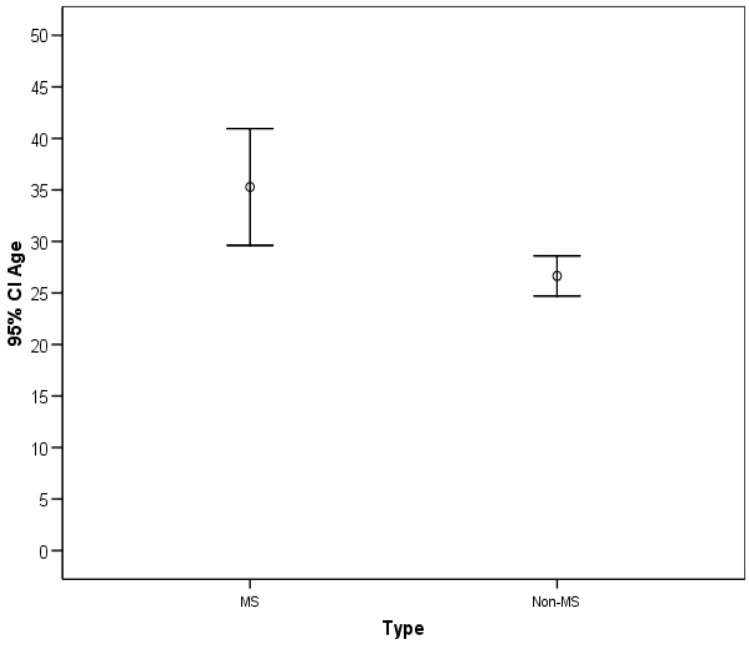

Figure 3 Error bar showing confidence interval for age distribution

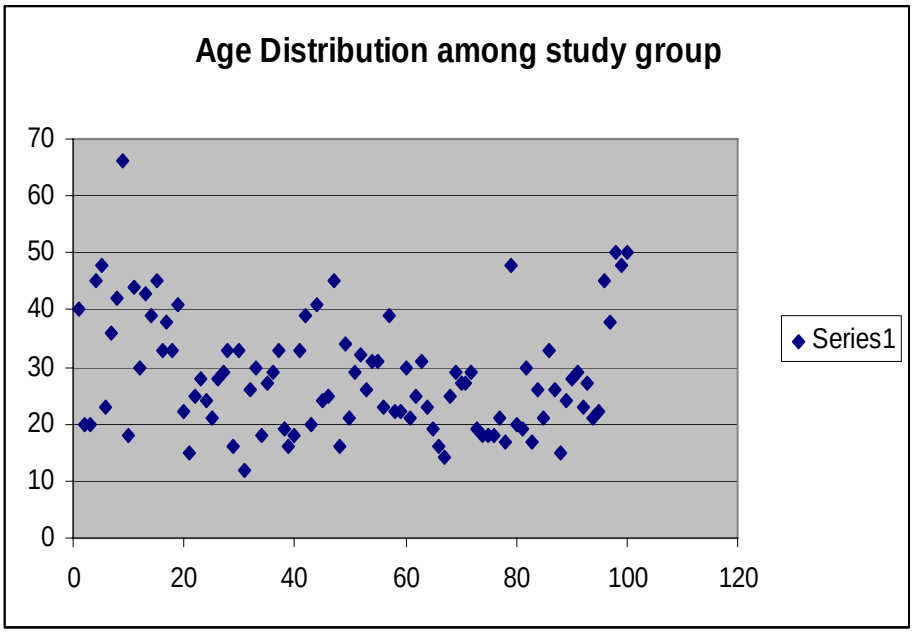

Figure 4 Age Distribution among Study Group

Sex Distributon:

58% of the cases in the study group were male and 42% were female. Among the patients with Metabolic Syndrome 47.6% were male and 52.4% were female. On comparing this with the gender prevalence among those without Metabolic Syndrome no statistically significant association was found between sex of the patient and Metabolic syndrome.

Table 3 Sex distribution among the subgroups

	Males	Females	Total
MS	10 (47.6%)	11(52.4%)	21 (21%)
Non MS	48 (60.8%)	31 (39.2%)	79 (79%)

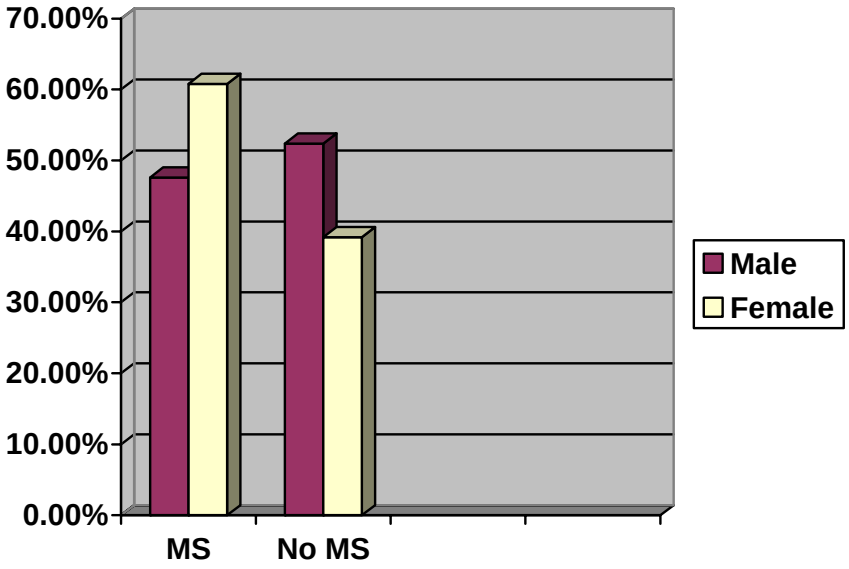

Figure 5 Sex Distribution

Duration of Diabetes:

The mean duration of diabetes among patients with Metabolic syndrome was found to be 11.81 yrs (± 6.98) and the mean for those without metabolic syndrome was 6.89 yrs (±5.86). On statistically analyzing the data with Chi square test statistical significance was achieved, showing an association between increasing duration of diabetes and presence of Metabolic Syndrome.

Table 4 Duration of diabetes among the subgroups

	Type	No.	Mean	Std. Deviation	P value
Duration	MS	21	11.81	6.976	<0.001
	Non-MS	79	6.89	5.855	

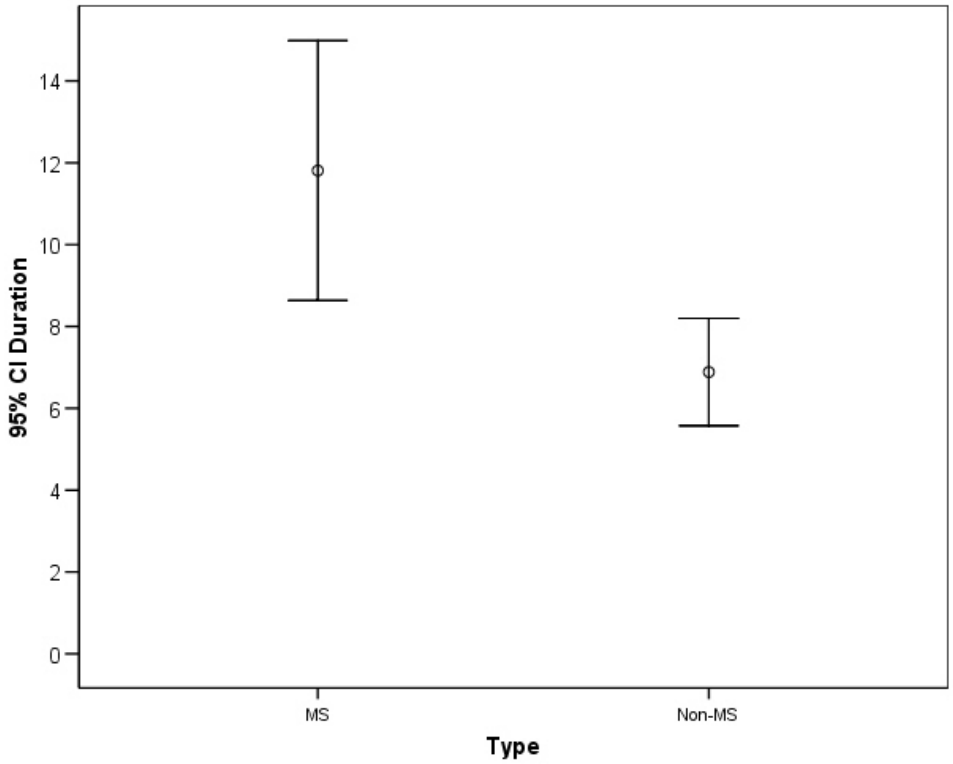

Figure 6 Error bar showing confidence interval of duration of diabetes

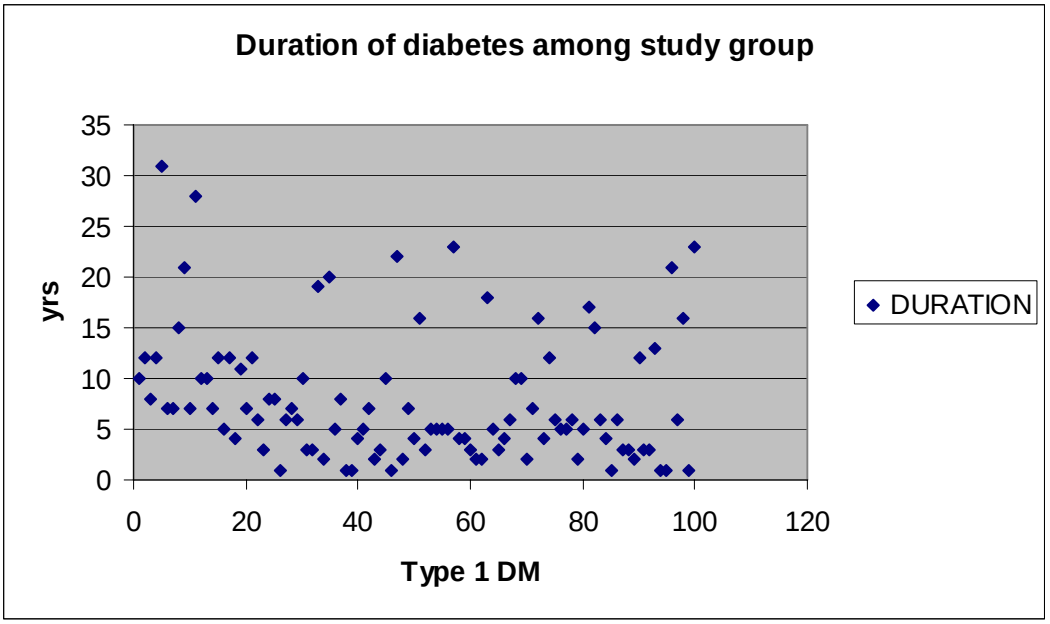

Figure 7 Duration of Diabetes among Study Group

Insulin requirement:

The average insulin requirement per day among patients with Metabolic syndrome is 65.90 units (±26.15) and that for patients without metabolic syndrome is 59.19 units (±24.08). No significant correlation was found between insulin requirement and occurrence of metabolic syndrome.

Table 5 Insulin requirement per day among the sub groups

	Type	N	Mean	Std. Deviation	P value
Insulin (U/day)	MS	21	65.90	26.149	0.267
	Non-MS	79	59.19	24.075	

Lifestyle:

Among the diabetic patients with metabolic syndrome the distribution of lifestyle pattern into heavy physical work, moderate physical activity and sedentary lifestyle was 9.5%, 38.1% and 52.4% respectively. Among those without metabolic syndrome 12.7% did heavy physical work, 60.8% had moderate physical activity and 26.6% led a sedentary life.

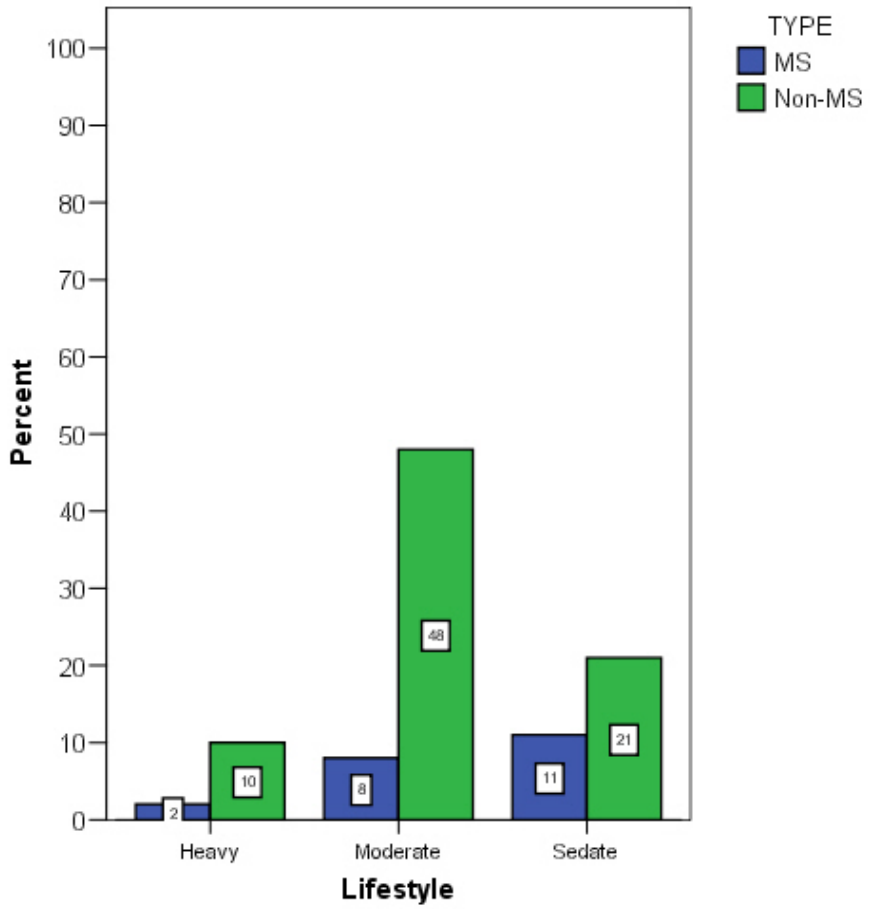

Figure 8 Shows the distribution of patients into three groups based on lifestyle

Glycemic control:

32(32%) of the total 100 diabetic patients had poor glycemic control., and 68 (68%) had good glycemic control. 7 (33.3%) of the 21 patients with Metabolic syndrome has poor glycemic control while 24 (30.4%) of the 79 patients without metabolic syndrome had poor glycemic control.

No significant association was found between glycemic control and occurrence of metabolic syndrome.

Table 6 Glycemic control among the sub groups.

	Type	N	Poor	Good	P value
Glycemic Control	MS	21	7 (33.3%)	14 (6.7%)	0.795
	Non-MS	79	24 (30.4%)	55 (69.6%)	

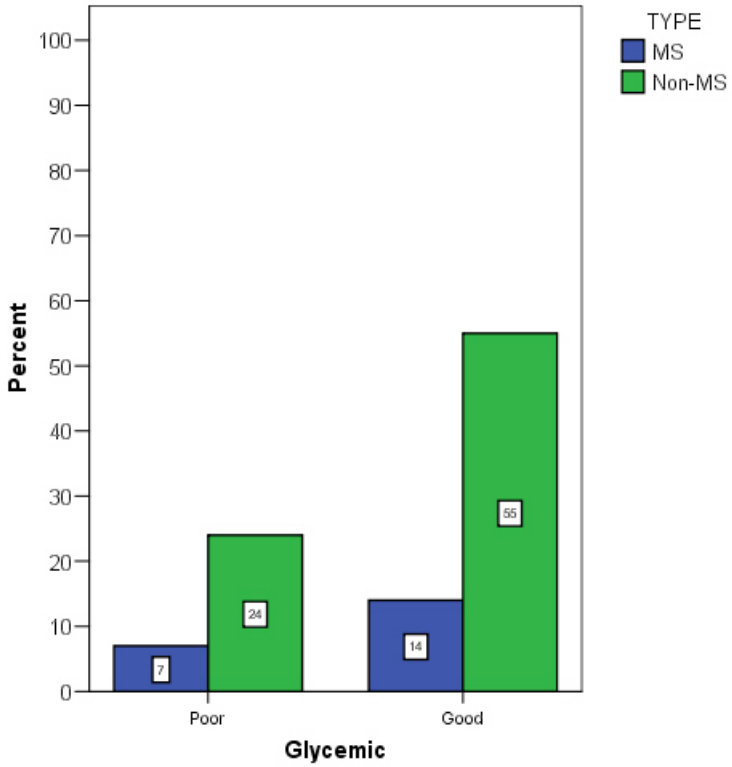

Figure 9 Distribution of glycemic control among study group

Components of Metabolic Syndrome:

The various components of metabolic syndrome were distributed in the following way among patients with Metabolic syndrome.

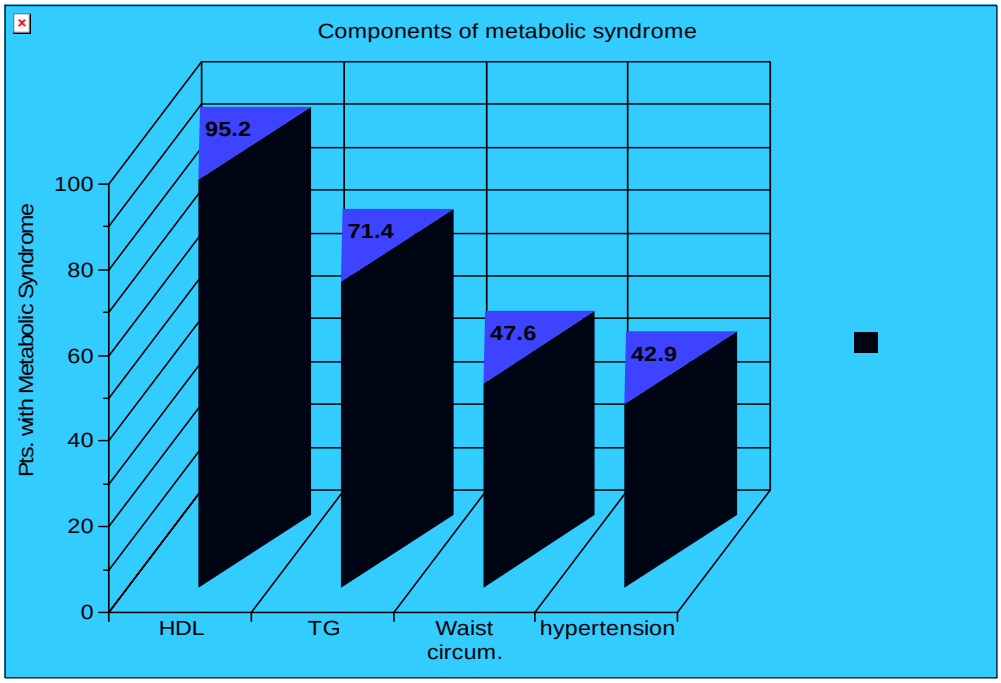

Figure 10 Components of Metabolic Syndrome

The most common component was low HDL values which was found in 95.2% of patients with metabolic syndrome and the least common was Hypertension which was found in 42.9% of patients.

Dyslipidemia

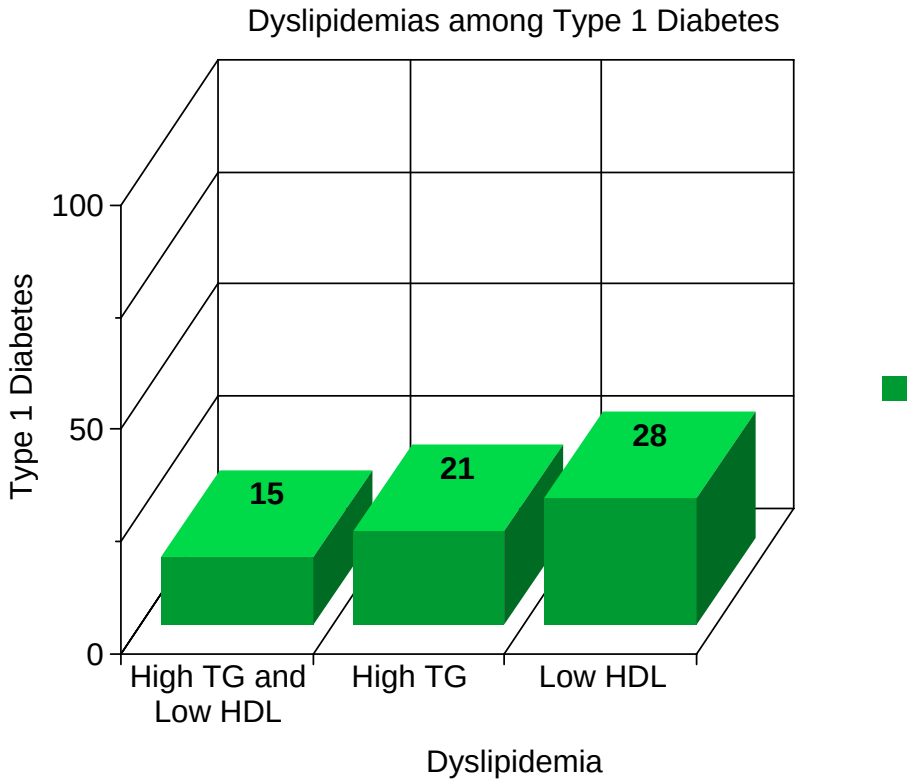

Figure 11 Dyslipidemias among Type 1 Diabetes

15% of type 1 diabetics had both hypertriglyceridemia and low HDL. But the most common dyslipidemia was low HDL alone, which was found in 28% of the patients. Hypertriglyceridemia in isolation was documented in 21% of the patients. Among the patients with Metabolic Syndrome also low HDL was the most commonly found association.

Hypertension

11 patients among the cohort of hundred were found to have hypertension. 10 of them had Metabolic Syndrome.

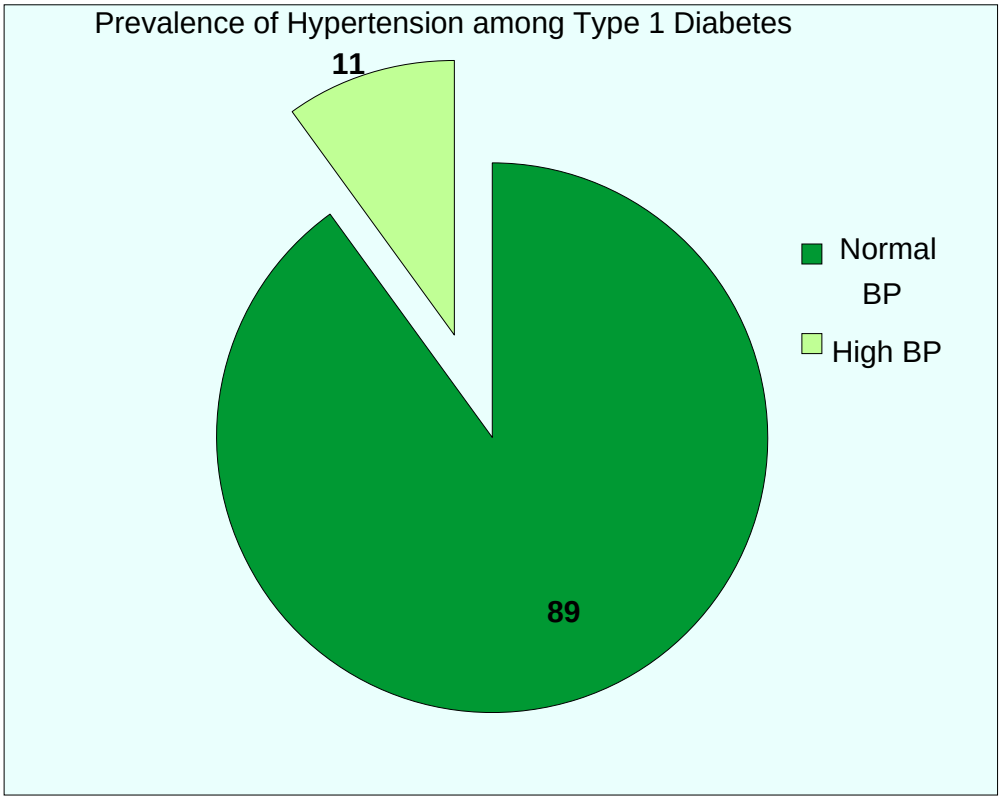

Figure 12 Prevalence of Hypertension among Type 1 Diabetes

Central Obesity:

16% of the type 2 Diabetics had central obesity. 10 among this 16 had metabolic Syndrome.

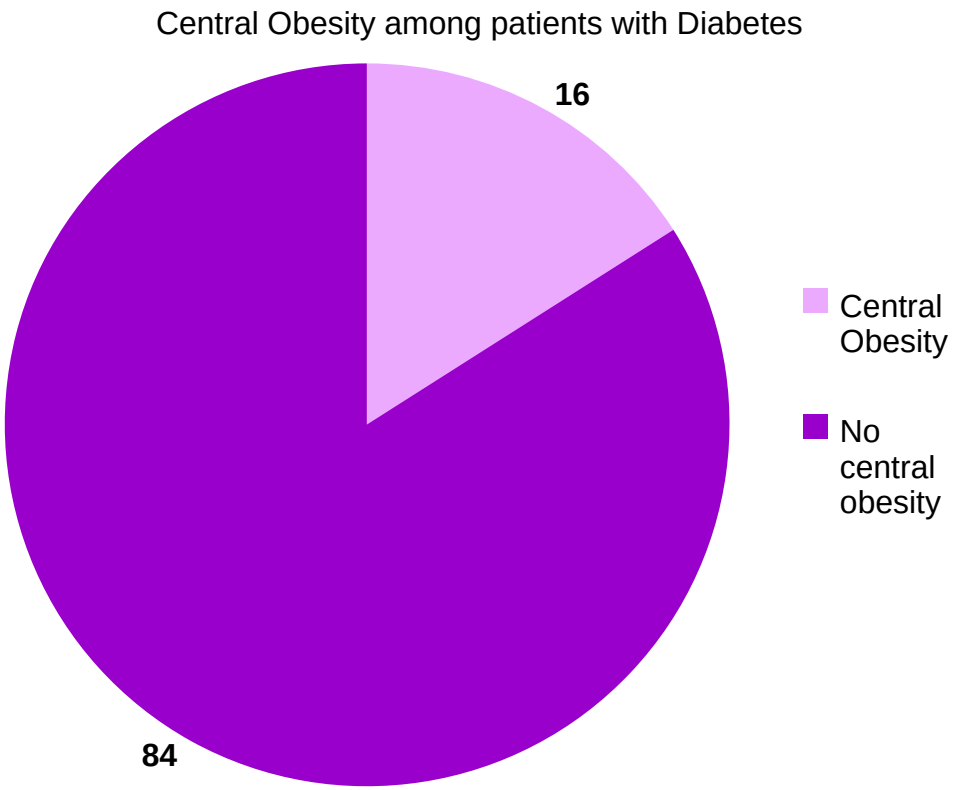

Figure 13 Central Obesity among Patients with Diabetes

DISCUSSION

Insulin resistance (IR) plays a larger role in the type 1 diabetes mellitus (T1DM) disease process than commonly recognized.[26] Overweight and physical inactivity have increased steadily for the last 20-30 years in children and adolescents in many populations, concurrently with a rising incidence of T1DM. The role of IR in T1DM has only recently been gaining acceptance.[26] It is now suspected that insulin resistance occurs in those with type 1 diabetes in the same way as it does in those with type 2, essentially giving these individuals **double diabetes** and greatly increasing their risk of heart disease.[27]

We have used the NCEP ATP III criteria for diagnosis for metabolic syndrome in this study as it have been widely accepted and is relatively simple to apply[28]. **The prevalence of metabolic syndrome in this study is 21%.** Given below is a comparison of the prevalence obtained in various international studies. No Indian data regarding the same has been found during literature search.

Table 7 Comparing prevalence of MS among various studies

Study	*Type 1 DM*	*Prevalence of Met Syndrome*
FinnDiane study[29]	2415	**40%**
DCCT[27]	1337	**25.2%**
Johan Wadén, Lena M. Thorn, et al Finn Diane study[30]	1028	**39%**
Metascreen writing committee Italy[31]	628	**39.3%**
Pittsburg Epidemiology of Diabetic Complications study[32]	514	**21%**
F Al-Saraj, JH McDermott et al Endocrine Abstracts 2004[24]	32	**16%**
Present study	**100**	**21%**

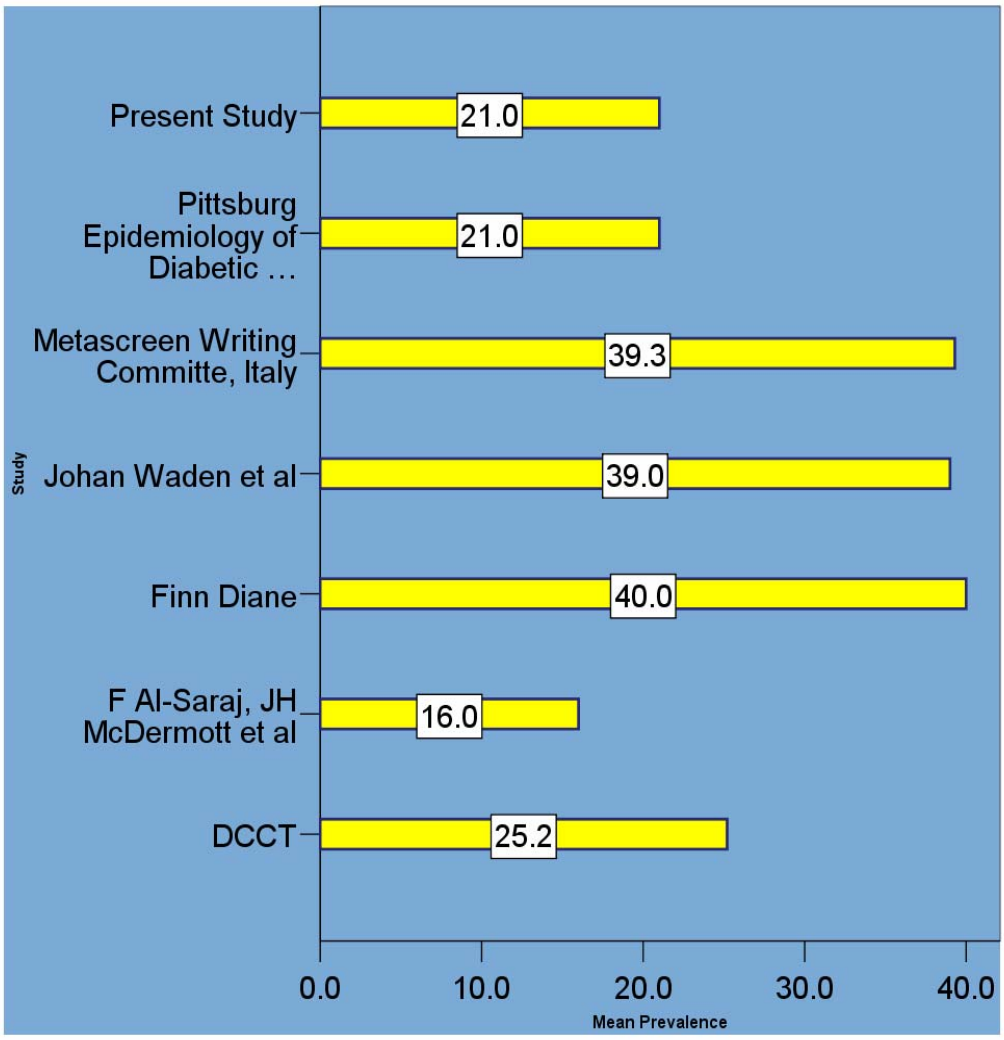

Figure 14 : Comparative analysis of prevalence of MS

There is considerable variation in the prevalence ranging from 16% to 40% which can be explained by the fact that each study has used an entirely different race as the study group. Though most of the above studies have also used NCEP ATP III criteria, the prevalence was compared with other criteria like IDF and WHO. Another main reason for the difference would be the study design. The cross sectional studies show prevalence similar to that obtained in our study but prospective

studies show a higher prevalence probably due to the continuously increasing weight gain.

Age distribution:

The overall average age of the study group was 28.5 yrs and that for those with MS and without MS was 35.33 and 25.30 yrs. **When analysed statistically it was found advancing age of the patient was found to correlate positively with incidence of MS (P<0.001).** This can be explained by the fact that abdominal obesity and hypertension increase with age. Prolonged insulin therapy and sedentary lifestyle are what contribute to the progressive weight gain. The FinnDiane study also showed a similar increase in MS with age.[29]

Table 8 Showing age distribution in various studies

Study	**Number**	**Mean age**
FinnDiane study[29]	2415	37.0 yrs
DCCT[27]	1337	26.5yrs
Metascreen writing committee Italy[31]	628	33.3yrs
Current study	100	35.33 yrs

Sex Distribution

The overall sex distribution was 57% males and 43% females, while in the cohort with MS the distribution was 47.6% males and 53.4% females. So the prevalence of MS among women was 23.40% and among men was 18.86%. **No significant correlation was found between sex of the patient and occurrence of Metabolic syndrome. (P=0.278).** The DCCT trial showed a higher incidence of MS among men, though it could not be explained with the current knowledge.[27]

Duration of Diabetes:

Mean duration of diabetes among the patients with MS was 11.81 yrs and for those without MS was 6.89 yrs. The incidence of metabolic syndrome was found to increase with increasing duration of diabetes (P<0.001).

Lifestyle.

Patients were classified into sedentary, moderate activity and heavy physical labour based on a detailed questionnaire recording their average physical activity at work and during leisure. They were classified as follows : sedentary (LTPA <10 MET h/week, moderately active (LTPA 10–40 MET h/week), and active (LTPA >40 MET h/week). It was seen

that the prevalence of metabolic syndrome among patients with active lifestyle, moderate activity and sedentary lifestyle was 9.5%, 38.1% and 52.4%. on analyzing the data with Chi square test it was shown that the **prevalence of metabolic syndrome increased with decreasing physical activity.** Johan Wadén, , Lena M. Thorn, Carol Forsblom et al conducted a study using data from FinnDiane group and they demonstrated a similar correlation**.** Among patients reporting LTPA of low, moderate, or high intensity, 39.0, 28.3, and 23.2% (age-adjusted $P = 0.008$) had metabolic syndrome, respectively.[30]

One of the reasons for Type 1 DM to develop MS is thus proposed to be decreased physical activity leading to obesity which in turn leads to insulin resistance.

Glycemic control and insulin requirement:

Since HbA1c was not available in our setup we have used a surrogate marker to measure glycemic control in the form of average of monthly Fasting blood sugar values over one year.[33] In our study no correlation was found between glycemic control and MS. 66.7% of patients with MS had a good glycemic control. The FinnDiane study actually showed increasing incidence of Metabolic syndrome with worsening glycemic control.[29]

The reason for our study failing to demonstrate a correlation is probably that we have used a poor surrogate marker for glycemic control when compared to the other studies. But this could not be avoided due to financial constraints. A relatively small number of patients have been studied this could be another reason for the lack of statistical significance.

Average Insulin requirement per day among patients with MS was 65.90 units while that for those without MS was 59.19 Units. Though the insulin requirement was higher in the MS group a statistical significance could not be demonstrated. An increase in insulin requirement is actually considered a clinical clue for the onset of metabolic syndrome.

Components of Metabolic Syndrome

Dyslipidemias were found to be the most common component and hypertension was the least common. The IDF criteria use abdominal obesity as a mandatory criteria. But **high Waist hip ratio (WHR) was found only in 47.6% of our study group.** The DCCT study quoted below used the IDF criteria so all the patients with MS had a high WHR. Even otherwise abdominal obesity is not as high as is expected from most studies. This can be explained by the fact that Asian patients with Type 1 DM are found to have a lean body habitus compared to the Caucasian counterparts. So central obesity can be considered an indicator of

metabolic syndrome in type 1 diabetics but is not found as commonly as it is in type 2 DM.

Table 9 Components of metabolic syndrome

	Low HDL	High TG	High BP	High WHR
Present study	**95.2%**	**71.4%**	**42.4%**	**47.6 %**
F Al-Saraj, JH McDermott et al Endocrine Abstracts 2004[24]	56.0%	52.7%	86.8%	79.1 %
DCCT[26]	84.87%	16.15%	9.62%	100%

Future research:

Since sparse data is available on demographic and epidemiological information of metabolic syndrome in Type 1 DM this can be considered an area for future research. A prospective study on the impact of MS on the complications of DM in our setup will help in reducing the morbidity and mortality associated with this disease. Population of Metabolic syndrome among type 1 DM and type 2 DM can be compared to see if the features between the two ends of the spectrum are similar.

Summary

Aims:

The aim of the study is to assess the prevalence of metabolic syndrome among Type 1 diabetics and assess its risk factors.

Methodology:

Consecutive 100 patients with Type 1 diabetes registered in the Diabetology Department were screened for height, weight, BMI, waist and hip circumference, blood pressure and lipid profile. Metabolic syndrome was considered as per the NCEP-ATP III criteria. Glycemic control was defined based on the average of fasting blood sugar over one year. The data was analysed statistically.

Results:

The overall prevalence was 21%, among males it was 17.2% and 26.2% in women. The criteria of HDL cholesterol, triglyceride, waist circumference and hypertension were present in 95.2%, 71.4%, 47.6%, and 42.9% of subjects respectively. The occurrence of MS was significantly correlated with advancing age ($p<0.001$), duration of diabetes ($p<0.001$), poor glycemic control (0.0023) and sedentary lifestyle. No correlation was found between gender and insulin dosage of the patient and metabolic syndrome.

CONCLUSIONS

1. Metabolic syndrome is more common in type 1 Diabetes than commonly recognised. The prevalence of metabolic syndrome among Type 1 Diabetes patients is found to be 21%.
2. The prevalence of metabolic syndrome is seen to increase with increasing age and increasing duration of diabetes.
3. Sedentary lifestyle has been shown to be an important risk factor for development of metabolic syndrome. So it is proposed that the lifestyle changes leading to obesity are the underlying basis for the development of Insulin resistance.
4. No significant association exists between glycemic control or insulin requirement and presence of metabolic syndrome.
5. Dyslipidemias have been found to be the most commonly found component of Metabolic syndrome in the study group. Central obesity and hypertension are seen to be less prevalent when compared to other studies.

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PROFORMA:

Name:

Age:

Sex:

Duration of diabetes:

Glycemic control:

Avg Fasting glucose of one year:

Insulin requirement per day:

Lifestyle:

Waist circumference:

Waist Hip Ratio: HDL(mg/dl):

TG(mg/dl): BP(mm hg):

MASTER CHART

Sl.No.	TYPE	AGE(YRS)	SEX	DURATION OF DIABETES(YRS)	GLYCEMIC CONTROL	INSLIN REQUIREMENT (U/DAY)	LIFESTYLE	CENTRAL OBESITY	HDL(mg/Dl)	TG(mg/dl)	SYS BP (mm hg)	DIAST BP(mm hg)

1	Met Syn	33	F	5	POOR	68	SEDENTARY	PRESENT	32	239	130	78
2	Met Syn	30	F	10	POOR	72	MODERATE	PRESENT	38	207	124	80
3	Met Syn	44	M	28	GOOD	62	SEDENTARY	ABSENT	40	190	130	72
4	Met Syn	33	F	4	GOOD	60	SEDENTARY	PRESENT	39	228	130	74
5	Met Syn	23	M	7	GOOD	40	MODERATE	ABSENT	30	217	124	74
6	Met Syn	45	F	12	POOR	124	SEDENTARY	PRESENT	34	206	124	76
7	Met Syn	39	F	7	POOR	141	SEDENTARY	PRESENT	31	127	122	74
8	Met Syn	41	F	11	GOOD	63	SEDENTARY	PRESENT	56	163	120	76
9	Met Syn	43	F	10	GOOD	55	MODERATE	PRESENT	35	98	110	80
10	Met Syn	18	M	7	GOOD	56	SEDENTARY	ABSENT	32	185	113	80
11	Met Syn	22	F	7	GOOD	64	SEDENTARY	PRESENT	30	184	110	70
12	Met Syn	15	F	12	GOOD	60	SEDENTARY	PRESENT	32	197	110	80
13	Met Syn	20	M	12	GOOD	32	HEAVY	ABSENT	36	140	140	90
14	Met Syn	20	M	8	POOR	72	MODERATE	ABSENT	32	126	148	100
15	Met Syn	48	M	31	GOOD	48	MODERATE	ABSENT	34	96	160	100
16	Met Syn	38	F	12	GOOD	51	SEDENTARY	PRESENT	32	102	150	90
17	Met Syn	40	M	10	GOOD	40	HEAVY	ABSENT	33	175	140	90
Sl.No.	**TYPE**	**AGE(YRS)**	**SEX**	**DURATION OF DIABETES(YRS)**	**GLYCEMIC CONTROL**	**INSLIN REQUIREMENT (U/DAY)**	**LIFESTYLE**	**CENTRAL OBESITY**	**HDL(mg/Dl)**	**TG(mg/dl)**	**SYS BP (mm hg)**	**DIAST BP(mm hg)**

18	Met Syn	45	F	12	POOR	48	MODERATE	ABSENT	32	172	140	88
19	Met Syn	36	M	7	GOOD	64	MODERATE	ABSENT	35	187	150	90
20	Met Syn	42	M	15	GOOD	68	MODERATE	ABSENT	35	198	140	90
21	Met Syn	66	M	21	POOR	96	SEDENTARY	ABSENT	37	194	160	110
22	No MS	12	M	3	POOR	52	MODERATE	ABSENT	52	136	130	70
23	No MS	25	F	10	GOOD	44	MODERATE	ABSENT	66	98	126	72
24	NO MS	16	F	4	GOOD	56	MODERATE	ABSENT	58	101	110	74
25	NO MS	18	F	5	GOOD	48	MODERATE	ABSENT	59	128	112	78
26	NO MS	50	M	16	POOR	80	SEDENTARY	PRESENT	74	130	120	78
27	NO MS	15	M	3	GOOD	42	SEDENTARY	ABSENT	37	95	130	80
28	NO MS	27	M	20	POOR	60	MODERATE	ABSENT	74	111	120	74
29	NO MS	21	M	4	GOOD	40	MODERATE	ABSENT	68	128	112	74
30	NO MS	18	F	12	GOOD	72	MODERATE	ABSENT	50	141	130	78
31	NO MS	45	F	21	POOR	68	HEAVY	PRESENT	64	118	120	70
32	NO MS	20	M	5	POOR	75	SEDENTARY	ABSENT	75	131	132	70
33	NO MS	28	M	12	GOOD	64	SEDENTARY	ABSENT	54	97	132	76
34	NO MS	17	F	6	POOR	68	SEDENTARY	ABSENT	75	242	128	78
Sl.No.	**TYPE**	**AGE(YRS)**	**SEX**	**DURATION OF DIABETES(YRS)**	**GLYCEMIC CONTROL**	**INSLIN REQUIREMENT (U/DAY)**	**LIFESTYLE**	**CENTRAL OBESITY**	**HDL(mg/Dl)**	**TG(mg/dl)**	**SYS BP (mm hg)**	**DIAST BP(mm hg)**

35	NO MS	48	M	1	GOOD	36	SEDENTARY	PRESENT	36	108	130	70
36	NO MS	45	M	22	GOOD	46	MODERATE	ABSENT	55	99	130	72
37	NO MS	26	M	5	GOOD	80	MODERATE	ABSENT	62	127	120	78
38	NO MS	31	M	5	GOOD	60	MODERATE	ABSENT	65	114	110	78
39	NO MS	22	M	4	GOOD	23	MODERATE	ABSENT	59	117	120	72
40	NO MS	18	F	6	GOOD	42	MODERATE	ABSENT	76	104	120	70
41	NO MS	30	M	15	POOR	86	SEDENTARY	ABSENT	65	131	130	70
42	NO MS	33	M	8	POOR	35	MODERATE	ABSENT	65	97	130	79
43	NO MS	27	F	7	GOOD	60	MODERATE	ABSENT	61	146	130	80
44	NO MS	30	M	19	POOR	86	MODERATE	ABSENT	68	147	120	80
45	NO MS	19	F	3	GOOD	60	MODERATE	ABSENT	77	136	110	80
46	NO MS	48	M	2	POOR	120	SEDENTARY	ABSENT	53	138	110	80
47	NO MS	29	M	5	POOR	70	MODERATE	ABSENT	70	146	110	78
48	NO MS	33	F	5	POOR	68	MODERATE	ABSENT	57	113	128	78
49	NO MS	32	M	3	GOOD	60	MODERATE	ABSENT	54	113	128	78
50	NO MS	19	F	4	GOOD	52	MODERATE	ABSENT	57	90	128	76
51	NO MS	26	M	3	GOOD	52	SEDENTARY	ABSENT	76	98	128	70
Sl.No.	**TYPE**	**AGE(YRS)**	**SEX**	**DURATION OF DIABETES(YRS)**	**GLYCEMIC CONTROL**	**INSLIN REQUIREMENT (U/DAY)**	**LIFESTYLE**	**CENTRAL OBESITY**	**HDL(mg/Dl)**	**TG(mg/dl)**	**SYS BP (mm hg)**	**DIAST BP(mm hg)**

52	NO MS	23	F	3	GOOD	20	SEDENTARY	ABSENT	79	118	128	80
53	NO MS	28	M	3	POOR	90	HEAVY	ABSENT	58	148	110	80
54	NO MS	41	M	3	GOOD	60	MODERATE	ABSENT	74	111	112	80
55	NO MS	34	M	7	GOOD	32	MODERATE	ABSENT	75	94	126	74
56	NO MS	27	F	2	GOOD	32	MODERATE	ABSENT	63	144	126	70
57	NO MS	29	F	10	GOOD	28	MODERATE	ABSENT	73	175	126	78
58	NO MS	16	F	1	POOR	58	MODERATE	ABSENT	69	96	112	80
59	NO MS	23	M	5	GOOD	50	MODERATE	ABSENT	61	144	110	80
60	NO MS	39	M	23	GOOD	40	MODERATE	ABSENT	51	116	130	74
61	NO MS	20	F	2	POOR	48	MODERATE	ABSENT	56	153	110	72
62	NO MS	21	M	2	GOOD	24	MODERATE	ABSENT	76	90	124	72
63	NO MS	14	F	6	GOOD	60	MODERATE	ABSENT	69	127	124	70
64	NO MS	24	M	2	GOOD	42	SEDENTARY	ABSENT	54	139	124	76
65	NO MS	38	M	6	POOR	92	SEDENTARY	PRESENT	50	148	122	80
66	NO MS	21	M	8	GOOD	60	HEAVY	ABSENT	30	123	122	74
67	NO MS	25	M	1	GOOD	64	MODERATE	ABSENT	74	115	122	74
68	NO MS	22	F	1	GOOD	71	SEDENTARY	ABSENT	77	165	122	82
Sl.No.	**TYPE**	**AGE(YRS)**	**SEX**	**DURATION OF DIABETES(YRS)**	**GLYCEMIC CONTROL**	**INSLIN REQUIREMENT (U/DAY)**	**LIFESTYLE**	**CENTRAL OBESITY**	**HDL(mg/Dl)**	**TG(mg/dl)**	**SYS BP (mm hg)**	**DIAST BP(mm hg)**

69	NO MS	31	F	18	GOOD	48	MODERATE	ABSENT	61	136	120	72
70	NO MS	29	F	16	GOOD	27	MODERATE	ABSENT	50	148	120	74
71	NO MS	29	M	16	GOOD	97	MODERATE	ABSENT	39	103	120	80
72	NO MS	18	M	2	POOR	72	MODERATE	ABSENT	66	147	118	70
73	NO MS	26	M	4	GOOD	36	SEDENTARY	ABSENT	53	150	118	80
74	NO MS	33	F	7	GOOD	68	HEAVY	ABSENT	77	100	116	72
75	NO MS	33	F	10	GOOD	68	HEAVY	ABSENT	72	138	116	80
76	NO MS	16	M	2	GOOD	116	MODERATE	ABSENT	63	97	116	70
77	NO MS	29	M	6	GOOD	56	HEAVY	ABSENT	52	125	110	74
78	NO MS	26	M	3	POOR	60	MODERATE	ABSENT	58	108	110	80
79	NO MS	24	M	10	GOOD	18	MODERATE	ABSENT	66	130	116	74
80	NO MS	30	M	3	GOOD	21	MODERATE	ABSENT	67	127	130	80
81	NO MS	17	F	6	GOOD	60	MODERATE	ABSENT	71	100	126	80
82	NO MS	19	F	1	POOR	72	MODERATE	ABSENT	71	147	114	70
83	NO MS	31	M	5	GOOD	40	MODERATE	ABSENT	51	105	114	80
84	NO MS	21	F	5	GOOD	72	MODERATE	ABSENT	65	131	114	76
85	NO MS	50	M	23	GOOD	62	SEDENTARY	PRESENT	79	130	114	80
Sl.No.	**TYPE**	**AGE(YRS)**	**SEX**	**DURATION OF DIABETES(YRS)**	**GLYCEMIC CONTROL**	**INSLIN REQUIREMENT (U/DAY)**	**LIFESTYLE**	**CENTRAL OBESITY**	**HDL(mg/Dl)**	**TG(mg/dl)**	**SYS BP (mm hg)**	**DIAST BP(mm hg)**

86	NO MS	28	M	1	GOOD	44	HEAVY	ABSENT	68	134	130	80
87	NO MS	23	F	5	GOOD	42	MODERATE	ABSENT	62	127	130	70
88	NO MS	21	M	1	GOOD	60	SEDENTARY	ABSENT	65	99	114	70
89	NO MS	24	M	8	POOR	42	HEAVY	ABSENT	51	126	112	80
90	NO MS	16	F	6	GOOD	110	HEAVY	ABSENT	54	135	112	70
91	NO MS	39	F	7	POOR	141	MODERATE	ABSENT	53	148	124	76
92	NO MS	27	F	13	GOOD	72	SEDENTARY	ABSENT	76	146	126	78
93	NO MS	18	F	4	POOR	48	MODERATE	ABSENT	62	119	130	72
94	NO MS	22	M	4	GOOD	74	MODERATE	ABSENT	78	148	120	70
95	NO MS	19	M	17	POOR	117	SEDENTARY	ABSENT	51	161	120	70
96	NO MS	25	M	6	POOR	80	HEAVY	ABSENT	39	106	110	70
97	NO MS	25	M	2	GOOD	32	MODERATE	ABSENT	40	99	110	70
98	NO MS	29	M	3	GOOD	52	SEDENTARY	ABSENT	37	126	110	80
99	NO MS	21	F	1	GOOD	47	SEDENTARY	ABSENT	53	132	110	80
100	NO MS	33	M	6	GOOD	46	SEDENTARY	ABSENT	70	145	148	96